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DATE: November 17, 2006

SUBJECT: FINDINGS ON THE HEALTH EFFECTS OF THE ACTIVE INGREDIENT: **METHIDATHION**

Enclosed please find a copy of the Office of Environmental Health Hazard Assessment's (OEHHA) findings for the active ingredient methidathion. These findings were prepared in response to the risk characterization document revision 1 SRP Draft (RCD/TAC, dated November, 2006) and the final draft exposure assessment document (EAD, dated October 26, 2006) for methidathion prepared by the Department of Pesticide Regulation (DPR). The information contained in these documents served to identify methidathion as a candidate toxic air contaminant (TAC).

Pursuant to Food and Agricultural Code sections 14022 and 14023, OEHHA provides review, consultation and comments to DPR on the evaluation of the health effects of candidate toxic air contaminants (TAC) included in the TAC documents. As part of its statutory responsibility, OEHHA also prepares findings on the health effects of the candidate toxic air contaminants. This documentation is to be included as part of the DPR report.

Should you have any questions regarding OEHHA's findings on the health effects of methidathion, please contact Dr. David Rice at (916) 324-1277 (primary reviewer), Dr. David Ting at (510) 622-3226, or Dr. Anna M. Fan at (510) 622-3165.

Enclosure

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Office of Environmental Health Hazard Assessment's Findings On the Health Effects of Methidathion

Pursuant to Food and Agricultural Code Sections 14022 and 14023, the Office of Environmental Health Hazard Assessment (OEHHA) of the California Environmental Protection Agency provides consultation and technical assistance to the Department of Pesticide Regulation (DPR) on the evaluation of health effects of candidate toxic air contaminants (TAC) and prepares health-based findings. OEHHA previously reviewed and commented on the draft documents prepared by DPR on the evaluation of human health risks associated with potential exposure to methidathion. These documents are used by DPR in considering listing methidathion as a toxic air contaminant (TAC). As part of its statutory responsibility, OEHHA has also prepared these findings on the health effects of methidathion which are to be included as part of DPR's Risk Characterization / Toxic Air Contaminant (RCD/TAC) documents.

Environmental Fate and Exposure

1. Methidathion is a non-systemic organophosphate insecticide registered for the control of a wide range of agricultural mite and insect pests in terrestrial food crops**.** The chemical is used to protect plants from insects with sucking, chewing mouthparts such as scale, moths, and aphids. In 2001, a total of 93,055 pounds of methidathion were applied in California. The highest uses were in stone fruits, citrus, artichokes, walnuts, almonds, and to a lesser extent olives. Methidathion may be applied aerially or by ground equipment. Although methidathion has a low vapor pressure and is relatively non-volatile, residues of this chemical may be found in ambient air during the summer growing season.

2. Methidathion is moderately water-soluble and has the potential to run off into surface water depending on use conditions and environmental factors. Methidathion has been detected in California surface water as a result of rain runoff from wintertime dormant spray applications. The reported aqueous photolysis half-life of methidathion is 8.2 days. Methidathion has a low likelihood of leaching to ground water due to its relatively short soil half-life (1.5 – 8 days); methidathion has not been detected in California ground water. Microbial degradation appears to be the dominant route for methidathion breakdown.

3. Ambient air monitoring data for methidathion is available from four sites located within 0.25 miles of citrus groves: Sunnyside Elementary School in Strathmore, Jefferson Elementary School in Lindsay, Exeter Union High School in Exeter and the University of California Lindcove Field Station in Exeter. Background samples were collected at the California Air Resources Board (ARB) ambient air monitoring station in Visalia. The monitoring was conducted from June 27 through July 25, 1991. The Jefferson Elementary School site was the only location with samples above the limit of quantitation; most ambient exposure estimates were based on the results obtained at this site. These monitoring data were used in the RCD/TAC document for estimation of seasonal and chronic human exposure to methidathion in ambient air.

4. Air concentrations of methyl parathion during and after an airblast application on a walnut orchard in San Joaquin County were measured and used as surrogates to estimate airborne levels of methidathion following an application. These estimates were used in the RCD/TAC document for estimating acute (one hour and daily), seasonal and annual human exposure at application sites (bystander exposure). This scenario was also assumed to represent the worst-case situation regarding non-occupational acute ambient exposure to airborne methidathion.

5. Exposure values presented in the RCD/TAC document were estimated as follows:

   a) One-hour absorbed doses and absorbed daily doses (ADDs) were calculated for acute exposures of bystanders based on the 11 hour and 21 hour time-weighted average (TWA) air concentration of methyl parathion, respectively. Air concentrations were adjusted to estimate a maximum application rate of 5 lbs AI/acre for methidathion;
   b) Seasonal average daily doses (SADD) were calculated for seasonal ambient exposures from the average air concentration at the Jefferson site and from the unadjusted 21 hour TWA for bystander exposures; and
   c) Annual average daily doses (AADD), based on a nine-month annual use period, were calculated for ambient chronic exposures and bystander chronic exposures from the respective SADDs.

   Human doses were estimated for adults and infants (up to 12 months) and were based on generally accepted default values for body weights and breathing rates. Inhalation absorption was assumed to be 100 percent.

6. Human exposure to atmospheric methidathion can occur by both inhalation and dermal routes, but the predominant exposure route for systemic doses is inhalation. Inhalation uptake was assumed in the RCD/TAC document to be 100 percent for these estimates. Dermal uptake of methidathion has not been quantitatively estimated in these studies, but it is expected to provide less than one percent of the systemic dose received by inhalation.

Health Effects Studies

Humans

7. Numerous reports of acute pesticide illness involving methidathion have been reported in California over the past several years. Between 1982 and 2001, a total of 109 incidents were reported associated with the use of methidathion. Thirty of these incidents involved the use of methidathion as the sole active ingredient. Most of these cases (74 percent) were systemic in nature including complaints of vomiting, nausea, abdominal cramps, headache and dizziness. The putative route of exposure for the majority of these acute illnesses is inhalation. The remaining cases were incidents of localized dermal irritation. Most of the cases were exposures to agricultural workers either as a direct result of their handling of the material or field workers experiencing drift from nearby applications. Only three incidents were non-occupational.

Animals

8. The acute toxicity of methidathion has been evaluated in a variety of animal species including rats, mice, guinea pigs, rabbits, hamsters and pigeons. Signs of acute intoxication with methidathion are cholinergic in nature and consist of dizziness, ataxia, irregular and increased respiration, dyspnea, fasciculations, trembling, salivation, exophthalmos and death. Oral LD_{50}s range from 25 to 80 mg/kg in rats. Dermal LD_{50}s range from a low of 85 mg/kg in rats to 155 mg/kg in rabbits. Technical grade methidathion was a moderate to severe dermal sensitizer in the guinea pig.

9. Six oral and six dermal subchronic toxicity studies in laboratory animals are available. Clinical signs following subchronic exposure to methidathion included lethargy, anorexia, labored/rapid breathing, hunched posture, ataxia, tremors, soft feces and low body temperature. Pathological findings revealed anemia, liver toxicity, reduced brain cholinesterase (ChE) activity, and lesions of the liver, stomach and heart following subchronic exposure to methidathion. From these studies, a subchronic NOAEL of 1 mg/kg/day was identified for inhibition of brain ChE and lesions in the liver and gallbladder of rabbits, which were observed at the next higher dose (10 mg/kg/day; 21-day dermal exposure) (Osherhoff, 1987).

10. Six chronic toxicity/oncogenicity feeding studies are available for methidathion, two in rats, two in mice and two in dogs. One chronic gavage study is available in the rhesus monkey. Effects observed in chronic studies were similar to those observed following subchronic exposure, however, hepatotoxicity was more prevalent. The lowest NOAEL from an acceptable study was 0.15 mg/kg/day based on elevated liver enzymes in the serum and histological lesions observed in the livers of dogs at the next higher dose of 1.33 mg/kg/day (Chang and Walberg, 1991). An oncogenic response was observed in male mice and is discussed in Findings 12 and 19, below.

11. Methidathion genotoxicity data are mixed. However, positive results have been noted in a gene conversion/forward mutation assay with Saccharomyces cerevisiae (Arni and Muller, 1981), and in *in vitro* sister chromatid exchange (SCE) assays using Chinese hamster V79 cells (Chen *et al*., 1981) and human lymphocytes (Kevekordes *et al*., 1996).

12. A dose-related increase in liver tumors in male mice was observed in two long-term bioassays (IBT, 1980; Goldenthal, 1986). No evidence of oncogenicity was observed in female mice or in either sex in the two rat bioassays. The incidences of hepatocellular adenoma and carcinoma, combined were 9/46, 15/45, 11/47, 21/43, and 38/45 for doses of 0, 0.4, 1.4, 6.7, or 13.1 mg/kg/day, respectively. The incidences combined were statistically different from the controls at $p \leq 0.01$ at the two highest doses. A cancer potency was derived from this dataset and is discussed in Finding 19.

13. Four reproductive toxicity studies are available in rats for methidathion (two single generation studies, one two generation study and one three generation study). Effects observed in parental animals were tremors, alopecia, reductions in feed consumption and body weights, and reduced mating indices. Effects observed in pups included tremors,

signs of maternal neglect, reduced pup weights, and reduced survival. A parental NOAEL of 0.4 mg/kg/day was identified based on alopecia, tremors, reduced mating index and poor maternal care (as evidenced by pups being cool to the touch, weak, starving and lethargic) observed at the next higher dose of 2.2 mg/kg/day (Salamon, 1987). A reproductive NOAEL of 0.4 mg/kg/day was identified from the same study and was based on reduced pup weights and signs of maternal neglect observed at the next higher dose (2.2 mg/kg/day). No evidence of increased postnatal sensitivity was observed in these studies.

14. Several developmental toxicity studies in rats (3) and rabbits (2) are available for methidathion. Maternal effects observed included labored respiration, exophthalmia, miosis, chromodacryorrhea, vaginal bleeding, lethargy, stool alterations, loss of righting reflex, tremors, salivation, lacrimation, convulsions, ataxia, reduced food consumption and body weights, and death. Notable effects on the fetus were reduced ossification of the sternebrae and reduced body weights. A maternal NOAEL of 1.0 mg/kg/day was identified in rats based on mortality, clinical signs, and a reduction in feed consumption and body weights at the next higher dose of 2.5 mg/kg/day (Mainiero et al., 1987). A developmental NOAEL of 2.5 mg/kg/day based on reduced ossification of the sternebrae and reduced body weights at the next higher dose of 5.0 mg/kg/day was observed in a separate rat study (Fritz, 1976). This latter study suffered from several deficiencies, the most significant of which (no food consumption data or analysis of test material) resulted in a low confidence in the dose estimation. Accordingly, it is relevant to point out that no developmental effects were observed in pups at the highest dose tested (2.5 mg/kg/day) in the Mainiero, 1987 study.

15. A number of neurotoxicity studies have been performed in hens and rats. No evidence of delayed neuropathy was observed in any of the five available hen studies. Three studies were conducted in rats, two were single-dose acute studies and one was a 90-day subchronic study. In the acute studies with rats, signs typically associated with inhibition of cholinesterase were observed: salivation, lacrimation, diarrhea, tremors, ataxia and muscle fasciculations. In all rat studies, signs of neurotoxicity were observed in the functional observational battery (FOB): changes in autonomic and CNS signs, sensorimotor effects, impaired neuromuscular functions, reduction in maze activity, and reduced body temperature. Significant inhibition of cholinesterase activity versus the controls was also observed in all rat studies in serum, red blood cells (RBC) and brain. An acute LOAEL of 1 mg/kg was identified based on cholinesterase inhibition in the cerebral cortex of male rats (59 percent of controls) at the time of peak effect (1.5 hours post-dosing); no NOAEL was observed in the study (Chang and Richter, 1994). A subchronic NOAEL of 0.18 mg/kg/day was identified in the 90-day rat study and was based on reduced ChE activity in the cerebral cortex and striatum (males, 74 percent of controls, weeks 2-3; females, 63 percent of controls at week 13, respectively) at the next higher dose of 0.61 (males) or 0.72 mg/kg/day (females) (Chow and Turnier, 1995).

Basis, Potency, and Range of Health Risks to Humans

16. Human health risks for acute exposures to methidathion are estimated in the RCD/TAC document based on the two-week NOAEL of 0.18 mg/kg for inhibition of cholinesterase

(74 percent of controls) in the cerebral cortex of male rats at the next higher dose of 0.61 mg/kg/day (Chow and Turnier, 1995). The NOAEL was derived from the two week time-point of a 90-day neurotoxicity feeding study in rats. Human health risks from seasonal exposure to methidathion are estimated in the RCD/TAC document from the same 90-day study based on a subchronic NOAEL of 0.18 mg/kg/day identified at 90-days that was based on reduced ChE activity in the cerebral cortex and striatum (males, 74 percent of controls, weeks 2-3; females, 63 percent of controls at week 13, respectively) at the next higher dose of 0.61 (males) or 0.72 mg/kg/day (females) (Chow and Turnier, 1995). Risks to human health from chronic exposure to methidathion are estimated in the RCD/TAC document based on the NOAEL from a chronic study of 0.15 mg/kg/day that was based on elevated liver enzymes in the serum and histological lesions observed in the livers of dogs at the next higher dose of 1.33 mg/kg/day (Chang and Walberg, 1991). OEHHA adopted the same acute, subchronic and chronic NOAELs as in the RCD/TAC document for calculating margins of exposure (MOEs) and reference exposure levels (RELs).

17. Carcinogenic potency was quantified in the RCD/TAC because of the dose-related increases in hepatocellular adenomas and carcinomas in male mice observed in two separate bioassays and the limited positive genotoxicity data available in the literature. Cancer potencies of 0.34 (maximum likelihood estimate, MLE) and 0.53 $(mg/kg/day)^{-1}$ (95 percent upper confidence limit of the dose-response curve, 95% UCL) were calculated from the Goldenthal, 1986 bioassay using the multistage Weibull time-to-tumor model and assuming a linear dose-response. These methods were used in the document to estimate cancer risks from lifetime exposures to methidathion. OEHHA agrees with the use of these cancer potencies for estimating oncogenic risks from airborne exposure to methidathion.

18. MOEs were calculated in the RCD/TAC document for infants and adults by dividing the NOAEL by the estimated exposure. Acute exposures (one-hour and 24-hour) were assessed for the application site (bystander) scenario. Seasonal and chronic exposures were assessed for both ambient air and bystander exposures. MOEs exceeding 100, when based on NOAELs from animal studies, are generally considered by DPR to be sufficiently protective of human health. MOEs presented in the RCD/TAC are shown in Table 1, below.

19. MOEs presented in the RCD/TAC for acute (one-hour) exposures of residents adjacent to a methidathion application ranged from 39 to 220 for infants and adults, respectively. Twenty-four hour exposures resulted in acute MOEs ranging from 22 to 47 for infants and adults, respectively. Most acute MOEs for these exposures were less than 100, suggesting that these exposures present a potential public health concern.

20. MOEs for seasonal and chronic exposures to methidathion presented in the RCD/TAC document ranged from 190 to 2,200 (bystander exposure) and 3,300 to 7,100 (ambient exposures) for infants and adults, respectively. MOEs for these exposures were all greater than 100, suggesting that these exposures are not a public health concern.

21. Carcinogenic risk estimated in the RCD/TAC from exposure to methidathion in the ambient air ranged from 7.1×10^{-6} at the maximum likelihood estimate (MLE) to 1.1×10^{-5} at the 95 percent upper confidence limit on the slope of the dose-response curve (95 percent UCL). Carcinogenic risk from exposure bystanders to methidathion ranged from 2.5×10^{-5} at the MLE to 3.9×10^{-5} at the 95 percent UCL. An estimated risk of 1×10^{-6} or less is typically considered negligible. Accordingly, OEHHA concludes that lifetime exposure to methidathion in ambient air and to bystanders presents a potential public health concern. Cancer risks associated with methidathion exposure are presented in Table 2, below.

Table 1. MOEs Calculated in the RCD/TAC for Application Site and Ambient Air Exposures

Exposure Scenario	MOE[1]	
	Infant	Adult
Application Site		
1-hr acute[2,3]	39	220
24-hr acute[2,3]	22	47
Seasonal[3]	190[3]	400
Chronic[4]	950	2,000
Ambient Air		
Seasonal[3]	3,300	7,100
Chronic[4]	3,300	7,100

1. MOEs are calculated as follows: NOAEL/estimated exposure.
2. One-hour and 24-hour MOEs were based on the estimated acute exposures of bystanders to the 11-hour and 21-hour time-weighted average (TWA) air concentration of methyl parathion, respectively. Air concentrations were adjusted to estimate a maximum application rate of 5 lbs AI/acre for methidathion.
3. Chow and Turnier, 1995, NOAEL of 0.18 mg/kg/day based on inhibition of ChE in the rat cerebral cortex.
4. Johnston, 1967; NOAEL of 0.15 mg/kg/day for elevated liver enzymes in serum and hepatic lesions.

Note. Exposure estimates are the average daily doses (ADDs) - acute, seasonal average daily dosage (SADDs) - seasonal or annual average daily dosages (AADDs) - chronic as presented in the RCD/TAC.

Table 2. Carcinogenic Risk[1] for Lifetime Exposure as Calculated in the RCD/TAC for

Application Site and Ambient Air

Exposure Scenario	Cancer Risk Estimate	
	Maximum Likelihood Estimate	95 percent Upper Bound
Application Site	2.5×10^{-5}	3.9×10^{-5}
Ambient Air	7.1×10^{-6}	1.1×10^{-5}

1. Carcinogenic Risk = carcinogenic potency x exposure estimate. Potencies were calculated in the RCD/TAC and were: 0.34 $(mg/kg/day)^{-1}$ maximum likelihood estimate; 0.53 $(mg/kg/day)^{-1}$ 95 percent upper confidence limit estimate. Exposure estimates were the average annual daily doses as described in the RCD/TAC.

Table 3. Reference Concentrations (RFCs) calculated in the RCD/TAC for Acute, Seasonal and Chronic Exposures to Methidathion

Exposure Duration	Infant RfC[1]	Adult RfC[2]
Acute[3]	3.1 $\mu g/m^3$	6.4 $\mu g/m^3$
Seasonal[3]	3.1 $\mu g/m^3$	6.4 $\mu g/m^3$
Chronic[4]	2.5 $\mu g/m^3$	5.4 $\mu g/m^3$

1. Infant RfCs were calculated using DPR's assumed breathing rate for infants of 0.59 m^3/kg/day. An uncertainty factor of 100 was applied to all calculations.
2. Adult RfCs were calculated using DPR's assumed breathing rate for infants of 0.28 m^3/kg/day. An uncertainty factor of 100 was applied to all calculations.
3. Chow and Turnier, 1995, NOAEL of 0.18 mg/kg/day based on inhibition of ChE in the rat cerebral cortex.
4. Johnston, 1967; NOAEL of 0.15 mg/kg/day for elevated liver enzymes in serum and hepatic lesions.

22. Reference concentrations (RfCs) for each exposure duration: acute, seasonal, and chronic were calculated in the document by dividing the oral NOAEL (mg/kg/day) by the breathing rate (m^3/kg/day) and uncertainty factor (unitless). All NOAELs were derived from experimental studies in animals, therefore, uncertainty factors of 100 were applied to the NOAELs in consideration of the variability between and within species. RfCs were calculated using breathing rates of 0.59 m^3/kg/day or 0.28 m^3/kg/day for infants and adults, respectively. OEHHA would calculate identical benchmark values, calling them reference exposure levels (RELs). RfCs presented in the RCD/TAC are shown in Table 3.

23. Assuming a carcinogenic potency of 0.53 $(mg/kg/day)^{-1}$ (95% UCL), an air concentration of 6.8 ng/m^3 methidathion is associated with a lifetime cancer risk of one-in-a-million (1×10^{-6}).

Other Relevant Findings

24. Measured levels of methidathion and methidathion oxon are summed when estimating human airborne exposures. The resulting air concentration is then used to assess risk based on the toxicity database for methidathion. Assuming that the oxon is the ultimate cholinesterase inhibitor, and is therefore more toxic than the parent, non-oncogenic toxicity may be underestimated in the RCD/TAC. Sufficient data is not available, however, to reliably estimate the relative toxicities of the parent compound and the oxon.

25. Since bystander scenarios represent worst-case ambient exposures, OEHHA would not calculate ambient exposures from the air concentrations measured at the Jefferson site, we would simply consider the exposure estimates for bystanders as ambient exposures.

26. No sensitive subpopulations have been identified, including infants and children. U.S. EPA's Food Quality Protection Safety Factor Committee has recommended that the ten-fold safety factor not be used in methidathion risk assessments because of the presence of adequate data, and because there was no evidence of enhanced susceptibility of infants or children to the toxic effects of methidathion.

27. Limited information is available regarding the environmental breakdown products of methidathion. Consequently, the extent of toxicological significance of co-exposure to possible breakdown products cannot be evaluated.

28. Cumulative exposure to other chemicals with similar mechanisms of action is likely. The extent of or any toxicological significance of cumulative exposure with these compounds has not been, but should be, evaluated.

29. The existing pesticide illness surveillance system is unable to characterize latent or chronic illnesses resulting from pesticide exposures. No epidemiological longitudinal cohort or follow-up studies exist that would delineate chronic illnesses arising from methidathion exposure.

30. Technical grade methidathion was a moderate to severe dermal sensitizer in the guinea pig. Sensitization is a potentially serious toxic effect. Use of this endpoint in risk assessment is problematic and sensitization risks are not assessed in the RCD/TAC.

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DATE: February 9, 2007

SUBJECT: FINDINGS ON THE HEALTH EFFECTS OF THE ACTIVE INGREDIENT: **METHIDATHION (ERRATA)**

On November 17, 2006, a set of findings for the active ingredient methidathion was sent by the Office of Environmental Health Hazard Assessment (OEHHA) to the Department of Pesticide Regulation (DPR) and the Air Resources Board (ARB). The findings were used by the Scientific Review Panel (SRP) in its deliberation of identifying methidathion as a Toxic Air Contaminant (TAC) at its January 11, 2007 meeting. After that meeting, OEHHA found a few

minor errors in the findings. Though the errors are not likely to have affected the decision of the SRP, they need to be corrected. The details of the corrections are provided below:

On Page 3, Comment #8. The third sentence, "Oral LD_{50}s range from 25 to 80 mg/kg in rats" should be changed to "Oral LD_{50}s range from 21 to 48 mg/kg in rats".

On Page 6, Comment #20. The first sentence should be changed. The original sentence is "MOEs for seasonal and chronic exposures to methidathion presented in the RCD/TAC document ranged from 190 to 2,200 (bystander exposure) and 3,300 to 7,100 (ambient exposures) for infants and adults, respectively". It should be changed to "MOEs for seasonal and chronic exposures to methidathion presented in the RCD/TAC document ranged from 190 to 2,000 (bystander exposure) and 3,000 to 7,100 (ambient exposures) for infants and adults, respectively".

On Page 6, Table 1. The MOE of infant in the ambient air seasonal exposure scenario should be changed from "3,300" to "3,000".

On Page 6, Table 1. The MOE of adult in the ambient air seasonal exposure scenario should be changed from "7,100" to "6,400".

We are sorry for any inconvenience the errors might have caused you. Should you have any questions regarding the corrections, please contact Dr. David Ting at (510) 622-3226, or Dr. Anna M. Fan at (510) 622-3165.

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